# Antimicrobial Treatments for Minimally Processed Cantaloupe Melon

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ABSTRACT: Efficacy of decontamination treatments in reducing endogenous microbial populations on cantaloupe and in extending fresh-cut shelf-life were investigated. Composite rind plug samples were washed with water or solutions of sodium hypochlorite, $H_2O_2$, commercial detergent formulations containing dodecylbenzene sulfonic acid and phosphoric acid, or trisodium phosphate, and surviving microbial populations determined. Fresh-cut cubes were prepared aseptically from whole melons given similar treatments, and their visual appearance and bacterial population determined during storage at 4 °C. Population reductions on washed rind plugs were < 1 log with water, 1 to 2 logs with washing and sanitizing agents applied individually, and 3 logs with some sequential treatments with $H_2O_2$. $H_2O_2$ applied at 50 °C was superior to other whole-melon treatments, yielding a fresh-cut shelf-life of > 2 weeks.

Key Words: Cantaloupe, minimally processed, fresh-cut, sanitizers, shelf-life, hydrogen peroxide

## Introduction

MINIMALLY PROCESSED (FRESH-CUT) CANTALOUPE MELON is now widely accepted and available year-round throughout the United States. However, this product is highly perishable (O'Connor-Shaw and others 1994, Portela and Cantwell 1999) and, in common with other melons, has been associated with outbreaks of Salmonellosis (CDC 1991, Tamplin 1997). Survival and growth of *Salmonella* spp. and *Escherichia coli* O157:H7 on cantaloupe rind and flesh have been reported (Golden and others 1993, Del Rosario and Beuchat 1995). Efforts to improve the shelf-life and microbiological quality of fresh-cut melons have focused on raw material quality and ripeness (López-Gálvez and others 1996), reduction of microbial populations on the melon rind by treatment with hypochlorite (Ayhan and others 1996) or hydrogen peroxide vapor (Simmons and others 1996), rigorous attention to sanitation during cutting (Ayhan and others 1996), treatment of cut melon with $CaCl_2$ (Luna-Guzman and others 1996) or hypochlorite (Cantwell and others 1996), controlled atmosphere storage (Portela and Cantwell 1998), and storage at low temperatures (Cantwell and others 1996).

Although hypochlorite is widely used to sanitize fresh-cut fruits and vegetables, its effectiveness is limited with some products (Beuchat and Brackett 1990, Wei and others 1995). Preliminary studies in our laboratory indicated that treatment of fresh-cut cantaloupe with 200 ppm $Cl_2$ reduced aerobic plate counts by less than 1 log and did not appreciably delay visible spoilage (Sapers and Simmons 1998). Furthermore, because $Cl_2$ may react with food constituents to form potentially carcinogenic or mutagenic products, its safety as a treatment for fruits and vegetables has been questioned, and future regulatory restrictions may require the development of alternatives (Hurst 1995).

We have demonstrated that washing with dilute hydrogen peroxide ($H_2O_2$) solution is a highly effective sanitizing treatment for fresh mushrooms (Sapers and others 1994) and apples (Sapers and others 1999, 2000). This treatment showed promise with fresh-cut cantaloupe and zucchini, although results were not consistent (Sapers and Simmons 1998). Our objectives in this study were to improve the efficacy of $H_2O_2$ treatments for sanitizing external surfaces of uncut cantaloupe and to apply such treatments to the preparation of fresh-cut cantaloupe.

## Materials and Methods

### Raw materials

Ripe ("full slip") cantaloupes, free of visual defects, were purchased at local food stores in sufficient quantities to meet experimental needs (6 to 25 melons) and briefly refrigerated at 4 °C until needed. Experiments were conducted during the fall and winter of 1996–1997, the summer of 1997, and the summer of 1998, so that the melons were likely to have originated from several growing locations.

### Preparation and treatment of cantaloupe rind plugs

Because of anticipated melon-to-melon variability in microbiological quality and the logistical problem of applying replicated washing treatments to large numbers of whole melons, a model system was devised to permit application of treatments to replicate plugs of cantaloupe rind. To avoid cross-contamination during sample preparation and treatment, all knives, cutting boards, and other equipment in contact with melons were sanitized by immersion for 10 min in 1000 ppm $Cl_2$ (0.21% sodium hypochlorite adjusted to pH 6.5 with citric acid). Disposable gloves, changed between samples, were worn by the investigators during preparation and treatment of melons. Plugs of cantaloupe rind and attached flesh 20 mm in dia, were obtained from 1 or more melons (40 to 60 plugs per melon) with a sanitized stainless steel cork borer, and flesh portions were trimmed off with a sanitized knife and discarded. Washing treatments were applied to sets of 10 plugs (20 plugs in some trials), taken from a composite sample of 70–100 plugs. The plugs were immersed in 500 mL wash solution and stirred under standardized conditions for 1 min. Treatments included washes with water, 5% $H_2O_2$, 0.025–0.2% sodium dodecyl sulfate (SDS, Sigma-Aldrich, St. Louis, Mo., U.S.A.), sodium dioctyl sulfosuccinate (Sigma)

and sodium 2-ethylhexyl sulfate (Carsonol SHS, Lonza Inc., Fair Lawn, N.J., U.S.A.), 1000 ppm chlorine (sodium hypochlorite solution, adjusted to pH 6.5 with citric acid), 4% trisodium phosphate (TSP, Rhodia Inc., Washington, Pa., U.S.A.), 2 commercial detergent formulations (DECCO APL KLEEN 246, Elf Atochem North America, Inc., Monrovia, Calif., U.S.A., and AFCO 4344 Fruit and Vegetable Wash, Alex C. Fergusson Inc., Frazer, Pa., U.S.A.) both containing dodecylbenzene sulfonic acid and phosphoric acid at pH 2, combinations of these commercial detergent products with 5% $H_2O_2$, and sequential treatments with the commercial products followed by 5% $H_2O_2$. The 5% $H_2O_2$ solutions were prepared fresh prior to each trial from 30% $H_2O_2$ (Certified ACS, Fisher, Fair Lawn, N.J., U.S.A.). Previous studies with mushrooms (Sapers and Simmons 1998) and apples (Sapers and others 1999) demonstrated the stability of such solutions over many hours at ambient and elevated temperatures in which the peroxide concentration was monitored with the EM Reflectoquant™ Analysis System (EM Industries, Inc., Gibbsville, N.J., U.S.A.). Washing treatments were carried out at ambient temperature (ca. 20 °C) or 50 °C. Plugs were removed from the wash solution, drained, and rinsed in 500 mL sterile $H_2O$.

### Fresh-cut processing

All processing was carried out with sanitized equipment as described above. For each treatment, replicate ripe melons were placed in plastic tubs containing water or the sanitizing solution, and immersed with vigorous scrubbing with a stiff scrub brush for 1 min. After treatment and rinsing, the melons were cut in half and the seeds removed. Melon halves were then cut into 8ths and the edible portion removed from the rind and cut into cubes using separate cutting boards, knives, and gloves to minimize cross-contamination. A composite sample of cubes from the treated melons was dipped in water (control) or 50 ppm $Cl_2$ (sodium hypochlorite solution adjusted to pH 6.5 with citric acid). The treated and rinsed melon cubes were dewatered in a salad spinner (Triumphe Model M83, Fouineteau USA Inc., Indianapolis, Ind., U.S.A.) for 15 sec. The cubes were weighed (about 200g) into sanitized plastic boxes, which were then heat-sealed within modified atmosphere packaging bags (laminated polyethylene film; Cypress Packaging, Rochester, N.Y., U.S.A.) having a specified oxygen transmission rate value of 1,395 cc/m²/d. Treatments were carried out in duplicate. For each of the duplicate trials, 6 replicate boxes of cut melon cubes were prepared for storage at 4 °C and were examined at D 4, 7 or 8, 14 or 15, and 17 or 18 for visual indications of spoilage (presence of colonies, slime, turbidity in juice drained from cut cubes) and off-odors. At the same time, samples were taken for microbiological evaluation.

### Microbiological methods

Rind plug samples and 250 mL of sterile 0.1% peptone (Difco Labs., Detroit, Mich., U.S.A.) water were homogenized for 1 min in a 1,250 mL glass jar with a Waring single-speed drive unit (Waring Products Division, Dynamics Corp. of America, New Hartford, Conn., U.S.A.) operated at half-speed by means of a variable transformer. Homogenates were sampled, diluted with 1% peptone, spread-plated on Tryptic Soy Agar (Difco), and incubated for 18 to 24 h at 37 °C for enumeration of the surviving microflora. Counts were expressed as CFU/cm² of surface area, based on the surface area of the 10 or 20 plugs (31.4 or 62.8 cm², respectively).

**Table 1—Variability in microbial load on external surface of cantaloupe melon**

| Date of Purchase | Sample treatment[a] | n[b] | $Log_{10}$ CFU/cm²[c] Mean | Stand dev. | Range |
|---|---|---|---|---|---|
| 10/13/96-11/4/96 | Washed control | 3 | 5.24 | 1.69 | 4.04-7.18 |
| 1/10/97-2/26/97 | Dry control | 6 | 6.04 | 1.82 | 3.90-8.38 |
| | Washed control | 9 | 5.82 | 1.74 | 3.32-8.15 |
| 7/14/97-9/2/97 | Dry control | 9 | 4.09 | 1.09 | 2.50-5.53 |
| 7/27/98-8/6/98 | Dry control | 10 | 4.41 | 0.58 | 3.53-5.43 |
| Summer | All samples | 19 | 4.26[e] | 0.85 | 2.50-5.53 |
| Fall/Winter | All samples | 18 | 5.79[d] | 1.68 | 3.32-8.38 |
| All samples | Dry control | 25 | 4.68[e] | 1.36 | 2.50-8.38 |
| | Washed control | 12 | 5.67[d] | 1.67 | 3.32-8.15 |

[a]Plugs immersed in 500 mL sterile $H_2O$ for 5 min and drained (washed control) or sampled without washing (dry control).
[b]Samples from 10/13/96-7/24/97 consisted of 10 plugs each; samples obtained thereafter contained 20 plugs each.
[c]Aerobic plate count per cm² of external surface of 10 or 20 rind plugs.
[d-e]Within the comparisons of summer compared with fall/winter and dry compared with washed controls, means with no letter in common are significantly different ($p < 0.05$) by Duncan's Multiple Range Test.

Preweighed fresh-cut melon cube samples were blended with 250 mL sterile 0.1% peptone (Difco) water, diluted, plated and incubated, as described above. Counts were expressed as CFU/g.

### Statistical analyses

Microbiological data were analyzed for differences in response to treatments by ANOVA and Duncan's Multiple Range Test to separate means. All statistical analyses were performed with SAS/STAT software (SAS Institute Inc., Cary, N.C., U.S.A.).

## Results and Discussion

### Variability in microbial load

To estimate variability in the microbial load on external surfaces of cantaloupes, aerobic plate count data for replicate rind plugs representing samples, obtained over several seasons, were examined (Table 1). Samples obtained during the late fall and winter were more variable and of lower microbiological quality than samples obtained during the summer. This may be a reflection of cantaloupe-handling conditions at the point of origin or during distribution and marketing. The small difference between washed (with water in the laboratory) and unwashed melons is a reflection of the absence of washed samples during the summer months and is of no practical significance. The considerable variability in microbial load, even within the same year and season, requires that rind decontamination studies be designed so that all trials within an individual experiment employ replicate rind plugs taken from a sufficiently large pool of similar- appearing melons to compensate for variability.

### Effect of washing on microbial load of rind

Washing trials were carried out with the rind plug model system to determine the efficacy of various cleaning and sanitizing agents in reducing the microbial load. Washing with ambient or warm (50 °C) water was ineffective in reducing the microbial load on rind plugs (Table 2). Addition of 0.1 to 0.2% surfactants such as sodium dioctyl sulfosuccinate, sodium 2-ethylhexyl sulfate, or sodium dodecyl sulfate (data not shown) did not improve the efficacy of water as a decontaminating agent, even when the solutions were applied at 50 °C

**Table 2—Effect of washing with water and surfactant solutions on microbial load on cantaloupe rind plugs**

| Wash treatment[a] | Temperature (°C) | n | $Log_{10}$ CFU/cm² reduction[b,c] |
|---|---|---|---|
| $H_2O$ | 20 | 6 | 0.45 ± 0.50 |
| | 50 | 11 | 0.55 ± 0.61 |
| 0.1% sodium dioctyl sulfosuccinate | 20 | 2 | -0.15 ± 0.28 |
| 0.2% sodium 2-ethylhexyl sulfate | 20 | 3 | 0.38 ± 0.44 |

[a]Plugs immersed in 500 mL sterile $H_2O$ or surfactant solution for 5 min, rinsed and drained.
[b]Based on total plate count for washed sample and corresponding dry control.
[c]Log reduction values not significantly different ($p < 0.05$) by Duncan's Multiple Range Test.

**Table 3—Effect of washing with sanitizing agents at 50°C on microbial load on cantaloupe rind plugs**

| Wash treatment[a] | n | $Log_{10}$CFU/cm² reduction[c] |
|---|---|---|
| 1000 ppm $Cl_2$ (pH 6.5) | 10 | 0.63[f] |
| 1% APL KLEEN 246 | 3 | 1.32[ef] |
| 4% trisodium phosphate | 3 | 1.33[ef] |
| 8% trisodium phosphate | 2 | 1.13[ef] |
| 5% $H_2O_2$ | 7 | 1.65[e] |
| 1% APL KLEEN 246; 5% $H_2O_2$[b] | 3 | 1.60[e] |
| 2% APL KLEEN 246; 5% $H_2O_2$ (no final rinse)[b] | 2 | 3.08[d] |
| 5% trisodium phosphate; 5% $H_2O_2$ | 3 | 1.81[e] |

[a]Plugs immersed in 500 mL wash solution for 1 min, rinsed in 500 ml sterile $H_2O$ and drained.
[b]Detergent treatments applied, sample rinsed, and then $H_2O_2$ applied.
[c]Based on total plate count for washed sample and corresponding dry control.
[d-f]Means with no letter in common are significantly different ($p < 0.05$) by Duncan's Multiple Range Test.

(data not shown).

Sanitizers are widely used in produce-washing operations. In this study, a series of conventional and experimental products was tested at 50 °C. Application of 1,000 ppm $Cl_2$ (pH adjusted to 6.5) reduced the microbial load on cantaloupe rind plugs by less than 1 log (Table 3).

A commercial detergent formulation (DECCO APL KLEEN 246) achieved log reductions in excess of 1 when applied at concentrations of 1 and 2%. TSP, applied at concentrations of 4 and 8%, also yielded log reductions in excess of 1. However, log reductions attained by an experimental sanitizing agent, 5% $H_2O_2$, exceeded 2 in some trials. Results could be improved further by applying the detergent product or TSP first, rinsing it off, and then applying the $H_2O_2$ wash. Previously, we reported favorable results in decontaminating apples, artificially inoculated with a nonpathogenic *E. coli*, by washing with 5% $H_2O_2$, alone or in sequence with a detergent wash (Sapers and others 1999, 2000). However, it is evident with both apples and cantaloupe rind plugs that washing by itself cannot achieve a level of decontamination consistently exceeding a 3-log (99.9%) population reduction. Whether this is sufficient to control spoilage and preclude survival of contaminating human pathogens is the subject of continuing studies.

### Effect of cantaloupe decontamination on fresh-cut shelf-life

Our previous attempts to improve the microbiological quality and shelf-life of fresh-cut cantaloupe entailed washing the intact melons with 1,000 ppm chlorine (pH 6.5), rind removal and preparation of melon cubes, treatment of the fresh-cut cubes with various antimicrobial washes, dewatering, and packaging with a modified atmosphere. While this process resulted in some shelf-life extension (Sapers and Simmons 1998), the results were erratic and the benefits small (data not shown). In addition, we were concerned about chemical changes induced by sanitizers in the melon flesh prior to dissipation or removal of sanitizer residues. Residual $H_2O_2$ levels in excess of 25 ppm were detected in melon cubes after direct exposure to 5% $H_2O_2$ solution (Sapers and Simmons 1998). Therefore, in the present study we concentrated our efforts on more effective decontamination of whole melons rather than the cut flesh, based on the rind plug results, and avoidance of cross-contamination during rind removal, preparation and handling of the cut melon cubes, and packaging. A rigorous protocol to avoid cross-contamination was developed after a number of unsuccessful trials in which fresh-cut samples spoiled prematurely (data not shown). Essential elements of the protocol were physical isolation of rind-removal steps from cube-preparation steps (separate work stations and technicians, use of separate knives and cutting boards); sanitizing of latex gloves, knives and cutting boards between processing of replicate melons given the same treatment; and sanitizing of the work area and replacement of latex gloves between treatments.

**Table 4—Effect of melon decontamination treatments with $Cl_2$ and $H_2O_2$ on shelf-life of fresh-cut cantaloupe at 4 °C**

| Expt. | Treatment | $Log_{10}$ CFU/g[b] Day 0 | Day 7 | Day 15/14[c] | Day 18/17[c] | Appearance[d] D15/14[c] | Appearance[d] D18/17[c] |
|---|---|---|---|---|---|---|---|
| A | Control | 1.88[e] | 6.51[e] | 9.17[e] | 7.71[e] | Spoiled | Spoiled |
| | 1000 ppm $Cl_2$ (pH 6.5)[a] | 1.49[e] | 7.04[e] | 8.67[e] | 9.44[e] | Spoiled | Spoiled |
| | 5% $H_2O_2$ at 50 °C[a] | 1.44[e] | 3.62[f] | 5.24[e] | 5.94[e] | Not spoiled | Not spoiled |
| B | Control | 1.94[e] | 4.95[e] | 7.24[e] | 8.69[e] | Spoiled | Spoiled |
| | 1000 ppm $Cl_2$ (pH 6.5)[a] | 1.50 | 4.72[e] | 8.17[e] | 8.11[e] | Spoiled | Spoiled |
| | 5% $H_2O_2$ at 50 °C[a] | 1.03[e] | 2.35[e] | 6.02[e] | 6.21[f] | Not spoiled | Not spoiled |

[a]Melons scrubbed in solution for 1 min; residual $Cl_2$ but not $H_2O_2$ removed by rinsing; fresh-cut cubes rinsed with 50 ppm $Cl_2$ and de-watered.
[b]Total aerobic plate count.
[c]Expt. A samples examined on D 15 and 18, and Expt. B samples examined on D 14 and 17.
[d]Spoilage indicated by presence of mold, white colonies, cloudy liquid, or off-odor.
[e-f]Within the same experiment and column, means with no letter in common are significantly different ($p < 0.05$) by Duncan's Multiple Range Test.

Comparisons of fresh-cut cantaloupe cubes, prepared from control (unwashed), $Cl_2$-washed, and $H_2O_2$-washed melons indicated minimal differences in total aerobic plate count at D 0 of storage (Table 4). However, during storage at 4 °C, the total aerobic plate counts of melon cubes were consistently lower (although significantly lower in only 2 comparisons because of sample variability) after $H_2O_2$ treatment than in controls or after $Cl_2$ treatment. Examination of samples on D 7 revealed no evidence of spoilage. On D 15 and 18, evidence of spoilage was seen in the controls and with $Cl_2$-treatment, but not with the $H_2O_2$-treatment. This effect is not likely to be due to residual peroxide transferred from the cantaloupe rind to the flesh during flesh-cut preparation. Residual $H_2O_2$ levels in cubes immediately after preparation were only 2 to 5 ppm when the whole melons were not rinsed after treatment, and 0.5 to 2 ppm when the melons

**Table 5—Effect of two-stage melon decontamination treatments with a commercial acidic detergent or trisodium phosphate (TSP) followed by $H_2O_2$ on shelf-life of fresh-cut cantaloupe at 4 °C**

| Expt. | Treatment[a] | $Log_{10}$ CFU/g[b] Day 0 | Day 7 | Day 15/14[c] | Day 18/17[c] | Appearance[c] D 15/14[c] | D 18/17[c] |
|---|---|---|---|---|---|---|---|
| C | Control | 1.72[e] | 3.83[e] | 7.80[e] | 8.31[e] | Spoiled | Spoiled |
| | 1% APL KLEEN 246 at 50 °C | 2.04[e] | 2.13[f] | 4.43[e] | 5.65[e] | Not spoiled | Not spoiled |
| | 5% $H_2O_2$ at 50 °C | 1.51[e] | 1.54[f] | 4.43[e] | 4.04[e] | Not spoiled | Not spoiled |
| | 1% APL KLEEN 246 at 50 °C; rinse; 5% $H_2O_2$ at 50 °C | 2.12[e] | 1.50[f] | 3.14[e] | 6.73[e] | Not spoiled | Not spoiled |
| D | Control | 3.75[ef] | 8.18[e] | 9.16[e] | 10.46[e] | Spoiled | Spoiled |
| | 4% TSP at 50 °C | 4.28[e] | 6.70[ef] | 8.70[ef] | 9.50[e] | Spoiled(±) | Spoiled |
| | 5% $H_2O_2$ at 50 °C | 1.50[f] | 4.78[f] | 7.59[f] | 8.31[e] | Not spoiled | Spoiled |
| | 4% TSP at 50 °C; rinse; 5% $H_2O_2$ at 50 °C | 2.96[ef] | 5.91[f] | 7.98[ef] | 8.80[e] | Not spoiled(±) | Spoiled |

[a]Melons scrubbed in solution for 1 min; residual detergent and TSP but not $H_2O_2$ removed by rinsing; fresh-cut cubes rinsed with 50 ppm $Cl_2$ and de-watered.
[b]Total aerobic plate count.
[c]Expt. C samples examined on D 7, 14, and 17, and Expt. D samples examined on D 8, 14, and 17.
[d]Spoilage indicated by presence of mold, white colonies, cloudy liquid, or off-odor; lack of uniformity among replicates indicated by "±."
[e-f]Within the same experiment and column, means with no letter in common are significantly different ($p < 0.05$) by Duncan's Multiple Range Test.

were rinsed with water. After only 20 min, no $H_2O_2$ could be detected in either case. These results suggest that treatment of the melons with $H_2O_2$ resulted in injury to the surviving bacteria on the cantaloupe external surface that were transferred onto the flesh surface during cutting. The injured bacterial cells apparently did not grow as well as bacteria on controls or the survivors of $Cl_2$ treatment, resulting in lower counts during storage following fresh-cut processing and consequently, in shelf-life extension.

Attempts to improve the efficacy of $H_2O_2$ treatments in decontaminating cantaloupes by means of a two-stage wash, in which the $H_2O_2$ wash was preceded by an acidic detergent (DECCO APL KLEEN 246) or TSP wash and water rinse, were not successful (Table 5). A single wash with $H_2O_2$ was at least as good if not more effective than the two-stage washes, based on the total aerobic plate counts and visual appearance of fresh-cut melon cubes. In these trials, the fresh-cut controls failed as early as D 7, while fresh-cut cubes from cantaloupes given the $H_2O_2$ treatment showed no evidence of spoilage even after 14 d. We had anticipated some improvement in microbial detachment or disruption of biofilms with the two-stage treatments, based on our rind plug results and the TSP results reported by Somers and others (1994). However, it is possible that the putative cantaloupe biofilms, if present, were resistant to the detergent and TSP treatments. It is also possible that the surviving bacteria were embedded within inaccessible sites on the melon surface and were never exposed to the wash solutions.

In other trials with whole melons, a two-stage application of 2% AFCO 4344 at 60 °C, followed by a water rinse and application of a 5% $H_2O_2$ dip at 60 °C, was less effective than 1,000 ppm $Cl_2$ in suppressing bacterial growth and visible spoilage in fresh-cut cantaloupe, but both treatments were superior to untreated controls (data not shown). A two-stage treatment with the combination of 2% AFCO 4344, followed by a dip in 2,000 ppm $Cl_2$, was more effective than treatment with the detergent/$H_2O_2$ combination or $Cl_2$, applied separately, in suppressing bacterial growth in the fresh-cut product (Table 6).

Variability in the response of bacterial contaminants of

**Table 6—Effect of two-stage melon decontamination treatments with a commercial acidic detergent/$H_2O_2$ combination followed by $Cl_2$ on shelf-life of fresh-cut cantaloupe at 4EC**

| Treatment[a] | $Log_{10}$ CFU/g[b] Day 0 | Day 7 | Day 14 | Day 17 | Appearance[c] Day 14 | Day 17 |
|---|---|---|---|---|---|---|
| Control | 3.60[d] | 4.86[d] | 8.64[d] | 8.77[d] | Not spoiled | Spoiled |
| 2000 ppm $Cl_2$ | 2.31[f] | 4.62[d] | 7.66[e] | 8.43[d] | Not spoiled | Not spoiled |
| 5% $H_2O_2$ + 2% AFCO4344 at 60°C | 3.83[d] | 4.29[d] | 7.56[e] | 8.20[d] | Not spoiled | Spoiled |
| 2000 ppm $Cl_2$; $H_2O_2$ + 2% AFCO 4344 at 60° C | 3.41[de] | 4.46[d] | 7.71[e] | 8.11[d] | Not spoiled | Spoiled (±) |
| 2% AFCO 4344 at 60 °C; 2000 ppm $Cl_2$ | 2.56[ef] | 3.16[e] | 5.83[f] | 6.45[e] | Not spoiled | Not spoiled (±) |

[a]Melons scrubbed in solution for 1 min; residual detergent and $H_2O_2$ removed by rinsing.
[b]Total aerobic plate count.
[c]Spoilage indicated by presence of mold, white colonies, cloudy liquid, or off-odor; lack of uniformity among replicates indicated by ±.
[d-f]Within the same column, means with no letter in common are significantly different ($p<0.05$) by Duncan?s Multiple Range Test.

cantaloupes to antimicrobial treatments is a continuing problem. We suspect that such variability is related to the melon surface condition, make-up and population size of the microflora, and presence of bacteria within biofilms. Further improvements in treatment efficacy are required to overcome this problem. However, we must also consider the potential risk of making melons "too clean" so that competition against human pathogens that survive the wash or are introduced after fresh-cut processing is not eliminated. Greater growth of *Listeria monocytogenes* on endive following reductions in background microflora by chemical disinfection were reported by Carlin and others (1996). Studies in these areas are continuing.

## Conclusions

WASHING WITH 5% $H_2O_2$ OR WITH A COMMERCIAL DETERgent formulation followed by 5% $H_2O_2$ at 50 °C was more effective than washing with water, surfacant solutions, 1000 ppm Cl2, trisodium phosphate, or the commercial detergent formulation in reducing the microbial load on cantaloupe rind. A $H_2O_2$ wash, applied to melons prior to cutting, shows promise in improving the microbiological quality and shelf-life of fresh-cut cantaloupe.

## References


Ayhan Z, Richter ER, Yousef AE, Chism GW. 1996. Preservation of fresh-cut melon. Presented at 1996 Annual Meeting of Institute of Food Technologists. New Orleans, La., June 22–26.

Beuchat LR, Brackett RE. 1990. Survival and growth of *Listeria monocytogenes* on lettuce as influenced by shredding, chlorine treatment, modified atmosphere packaging, and temperature. J Food Sci 55:755–758.

Cantwell M, López-Gálvez G, Rovelo-González J, Nie X. 1996. Factors affecting quality of minimally processed cantaloupe melon. I. Temperature and atmosphere. Presented at 1996 Annual Meeting of Institute of Food Technologists, New Orleans, La., June 22–26.

Carlin F, Nguyen-The C, Morris CE. 1996. Influence of background microflora on *Listeria monocytogenes* on minimally processed fresh broad-leaved endive (*Cichorium endivia* var. *latifolia*). J Food Prot 59:698–703.

CDC [Center for Disease Control and Prevention]. 1991. Multistate outbreak of *Salmonella poona* infections - United States and Canada,1991. MMWR 40(32):549–552.

Del Rosario BA, Beuchat LR. 1995. Survival and growth of enterohemorrhagic *Escherichia coli* O157:H7 in cantaloupe and watermelon. J Food Prot 58:105–107.

Golden DA, Rhodehamel EJ, Kautter DA. 1993. Growth of *Salmonella* spp. in cantaloupe, watermelon, and honeydew melons. J Food Prot 56:194–196.

Hurst WC. 1995. Disinfection methods: A comparison of chlorine dioxide, ozone and ultraviolet light alternatives. Cutting Edge, Fall issue. International Fresh-cut Produce Association, Alexandria, Va. pp. 4-5.

López-Gálvez G, Luna-Guzman I, Trejo E, Nie X, Cantwell M. 1996. Factors affecting quality of minimally processed cantaloupe melon. II. Variety and ripeness. Presented at 1996 Annual Meeting of Institute of Food Technologists. New Orleans, lA., June 22–26.

Luna-Guzman I, Barrett DM, Cantwell M. 1996. Effects of calcium chloride dips and heat treatments on the quality of fresh-cut cantaloupe melons. Presented at 1996 Annual Meeting of Institute of Food Technologists. New Orleans, La., June 22–26.

O'Connor-Shaw RE, Roberts R, Ford AL, Nottingham SM. 1994. Shelf life of minimally processed honeydew, kiwi fruit, papaya, pineapple and cantaloupe. J Food Sci 59:1202–1206, 1215.

Portela SI, Cantwell MI. 1998. Quality changes of minimally processed honeydew melons stored in air or controlled atmosphere. Postharvest Biol and Technol 14:351–357.

Portela SI, Cantwell MI. 1999. Quality changes during storage of intact and fresh-cut cantaloupe melon. Presented at 1999 Annual Meeting of American Society for Horticultural Science. Minneapolis, Minn., July 27-31.

Sapers GM, Miller RL, Mattrazzo AM. 1999. Effectiveness of sanitizing agents in inactivating *Escherichia coli* in Golden Delicious apples. J Food Sci 64:734–737.

Sapers GM, Miller RL, Jantschke M, Mattrazzo AM. 2000. Factors limiting the efficacy of hydrogen peroxide washes for decontamination of apples containing *Escherichia coli*. J Food Sci. 65:529-532.

Sapers GM, Miller RL, Miller FC, Cooke PH, Choi S-W. 1994. Enzymatic browning control in minimally processed mushrooms. J Food Sci 59:1042–1047.

Sapers GM, Simmons GF. 1998. Hydrogen peroxide disinfection of minimally processed fruits and vegetables. Food Technol 52(2):48–52.

Simmons GF, Rij R, Smilanick JL, John S. 1996. Microbial population reduction on cantaloupe destined for the minimally processed market using hydrogen peroxide or $SO_2$. Presented at 1996 Annual Meeting of American Society for Horticultural Science. Lexington, Kentucky, October 6–10.

Somers EB, Schoeni JL, Wong ACL. 1994. Effect of trisodium phosphate on biofilm and planktonic cells of *Campylobacter jejuni, Escherichia coli* O157:H7, *Listeria monocytogenes*, and *Salmonella typhimurium*. Int J Food Microbiol 22:269–276.

Tamplin M. 1997. *Salmonella* and cantaloupes. Dairy, Food and Environmental Sanitation 17:284–286.

Wei CI, Huang TS, Kim JM, Tamplin ML, Bartz JA. 1995. Growth and survival of *Salmonella montevideo* on tomatoes and disinfection with chlorinated water. J Food Prot 58:829–836.


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